
g_i^P from SMC_1996

new results

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DAPNIA/Saclay
& SMC

THE SMC EXPERIMENT AT CERN

$$\vec{\mu} \vec{N} \Rightarrow \mu X \qquad \vec{\mu} \vec{N} \Rightarrow \mu h X$$

	BEAM	TARGET	TARGET POL.
1992	100 GeV	d-Butanol	30%
1993	190 GeV	p-Butanol	86%
1994	190 GeV	d-Butanol	49%
1995	190 GeV	d-Butanol	$\geq 50\%$
1996	190 GeV	p NH_3	89%



- BEAM POLARIZATION $\approx 80\%$

Measured by Moller scattering and decay methods

- TWO CELL POLARIZED TARGET



- HIGH Q^2 AND SMALL x

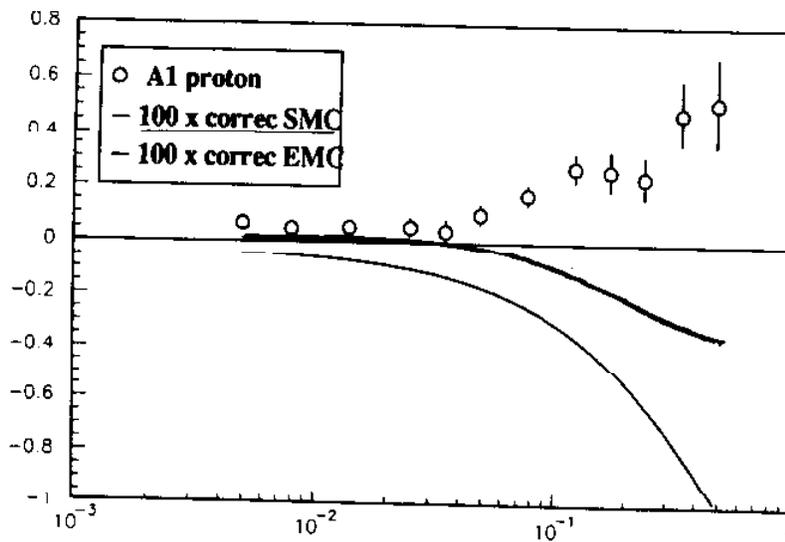
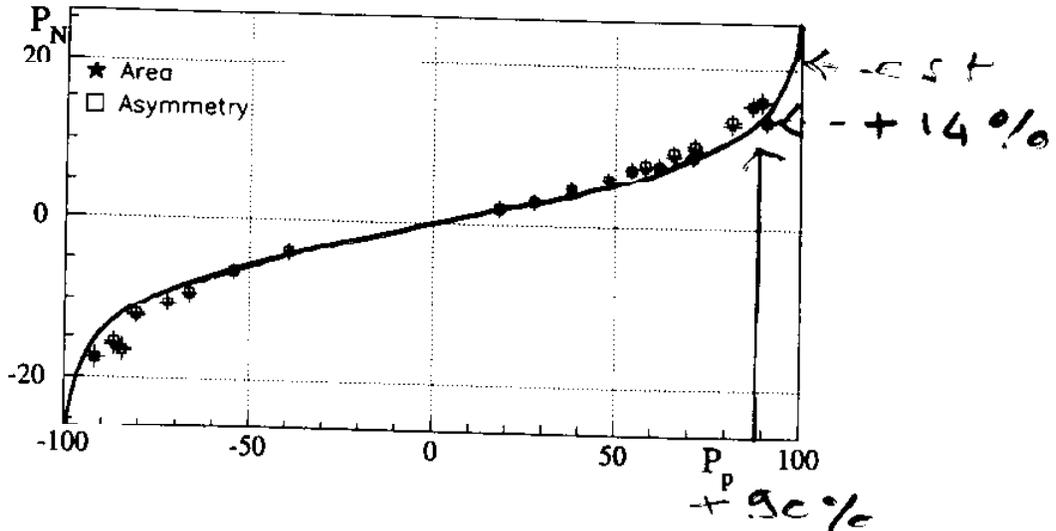
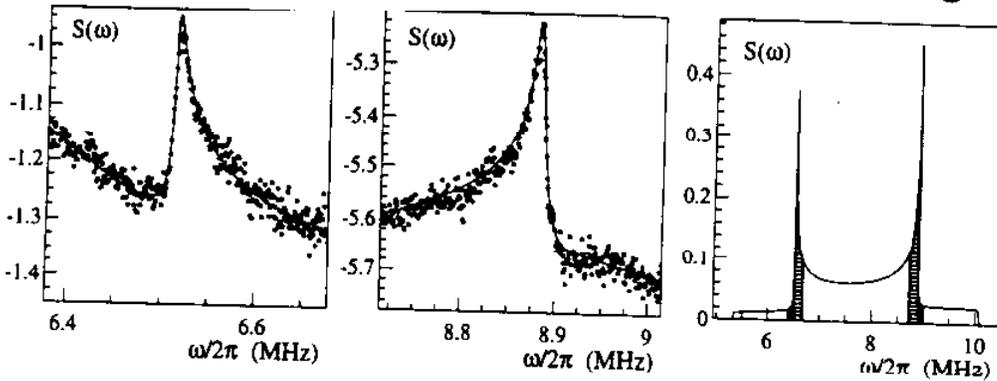
BUTANOL VS AMMONIA

	C_4H_9OH	$^{14}NH_3$
ρ (density)	0.985gcm^{-2}	0.853gcm^{-2}
x (packing factor)	0.63	0.58
f (dilution factor)	0.135	0.176
$\langle P \rangle$ (aver. pol.)	$\pm 86\%$	$\pm 89\%$
Polarized bckgd	≈ 0	$^{14}\vec{N}$

$$\frac{\sigma_{ANH_3}}{\sigma_{AC_4H_9OH}} = \frac{\sqrt{(x\rho f^2 P^2)_{C_4H_9OH}}}{\sqrt{(x\rho f^2 P^2)_{NH_3}}} \approx 0.83$$

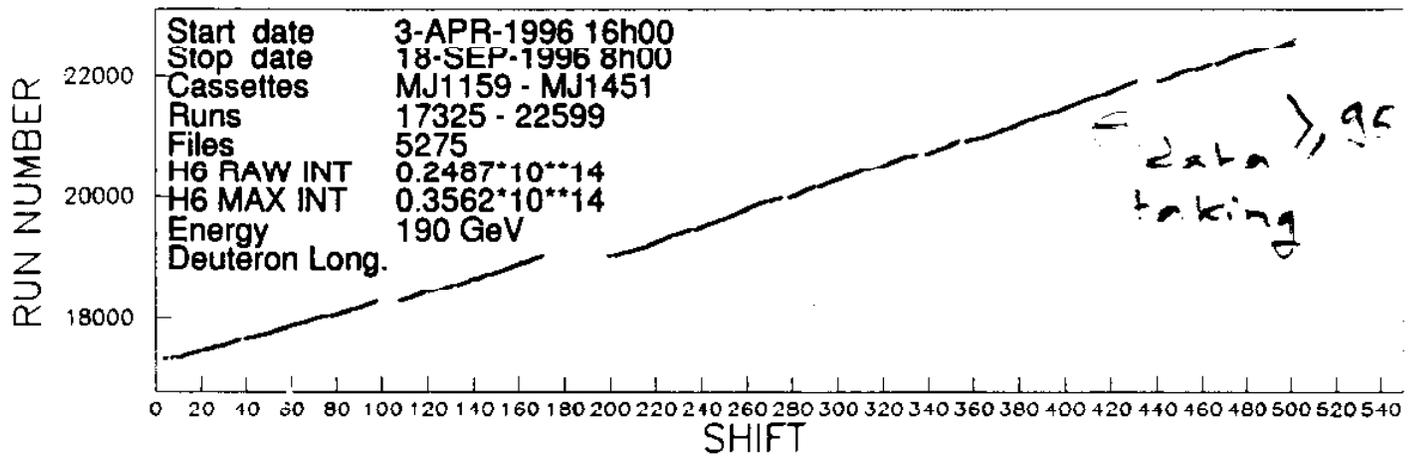
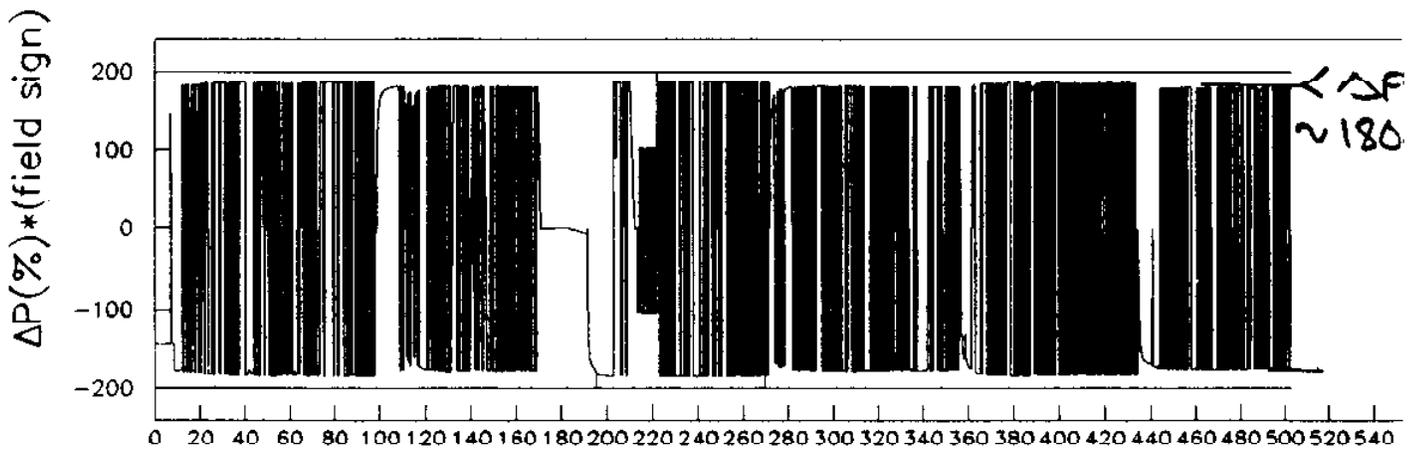
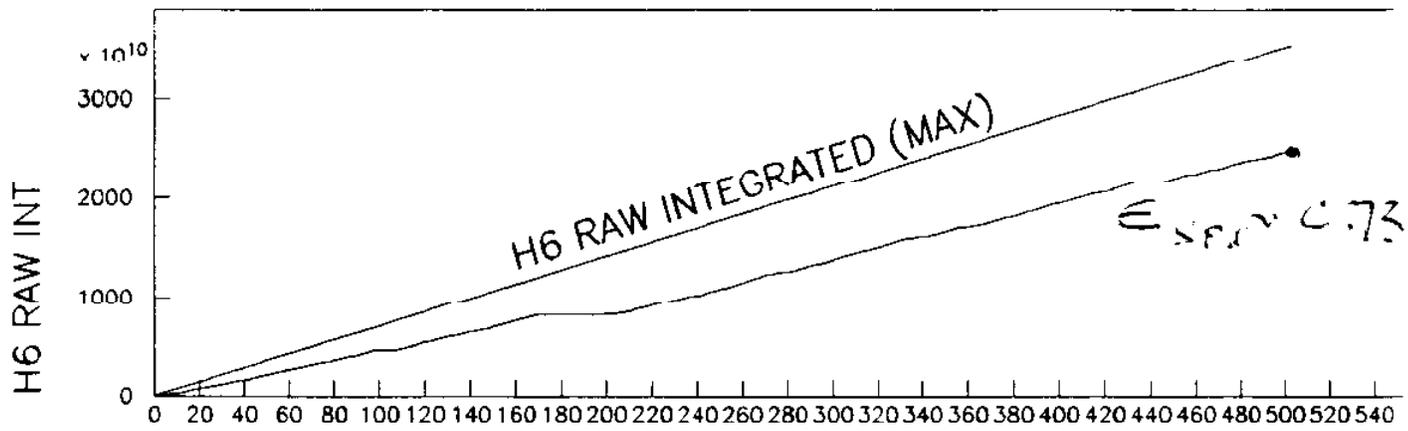
14N polarization

- SMC target, P_{14N} & P_p follow EST
 $\langle P_{14N} \rangle \sim 14\%$ $\Delta P_{14N}/P \leq 8\%$

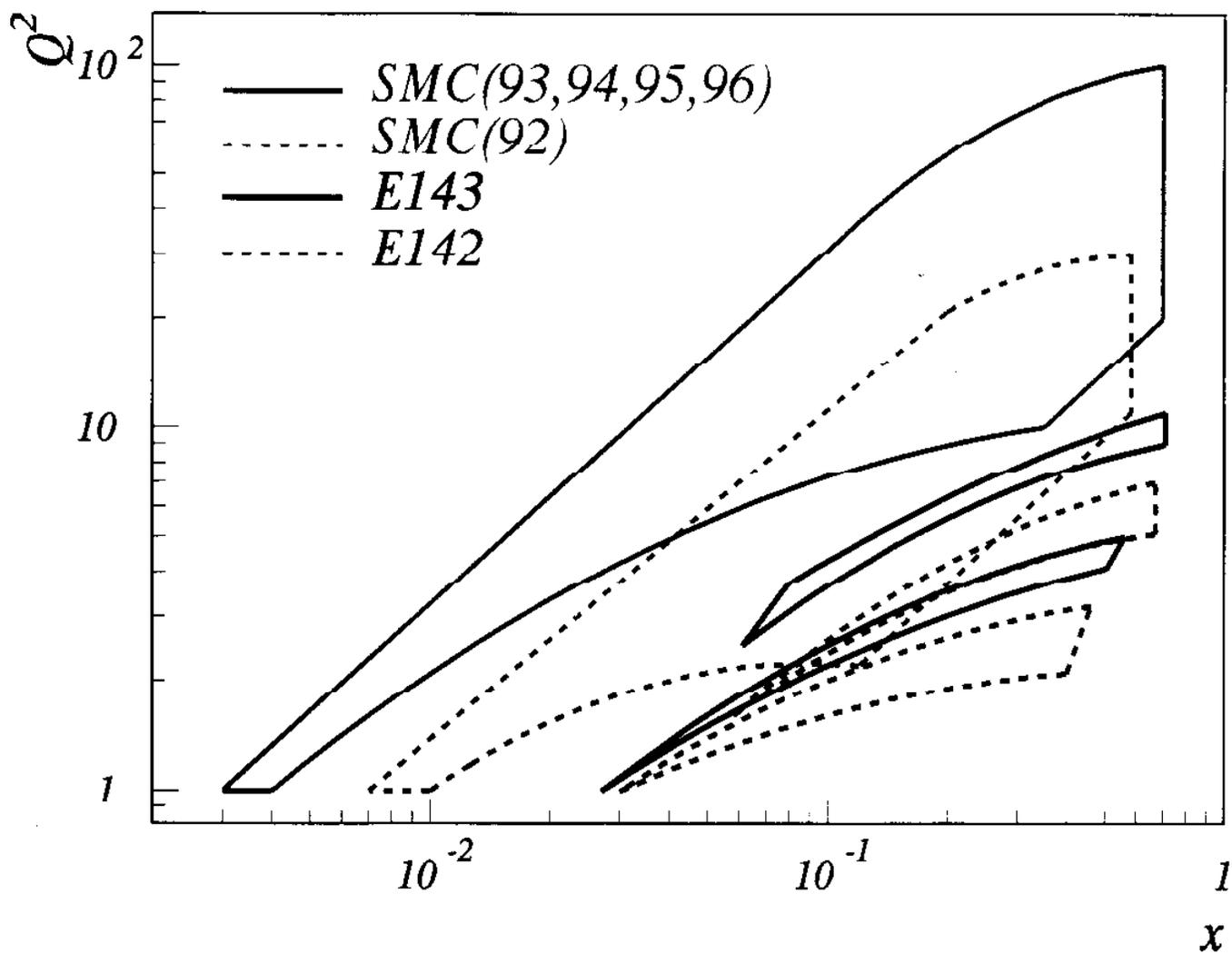


1996

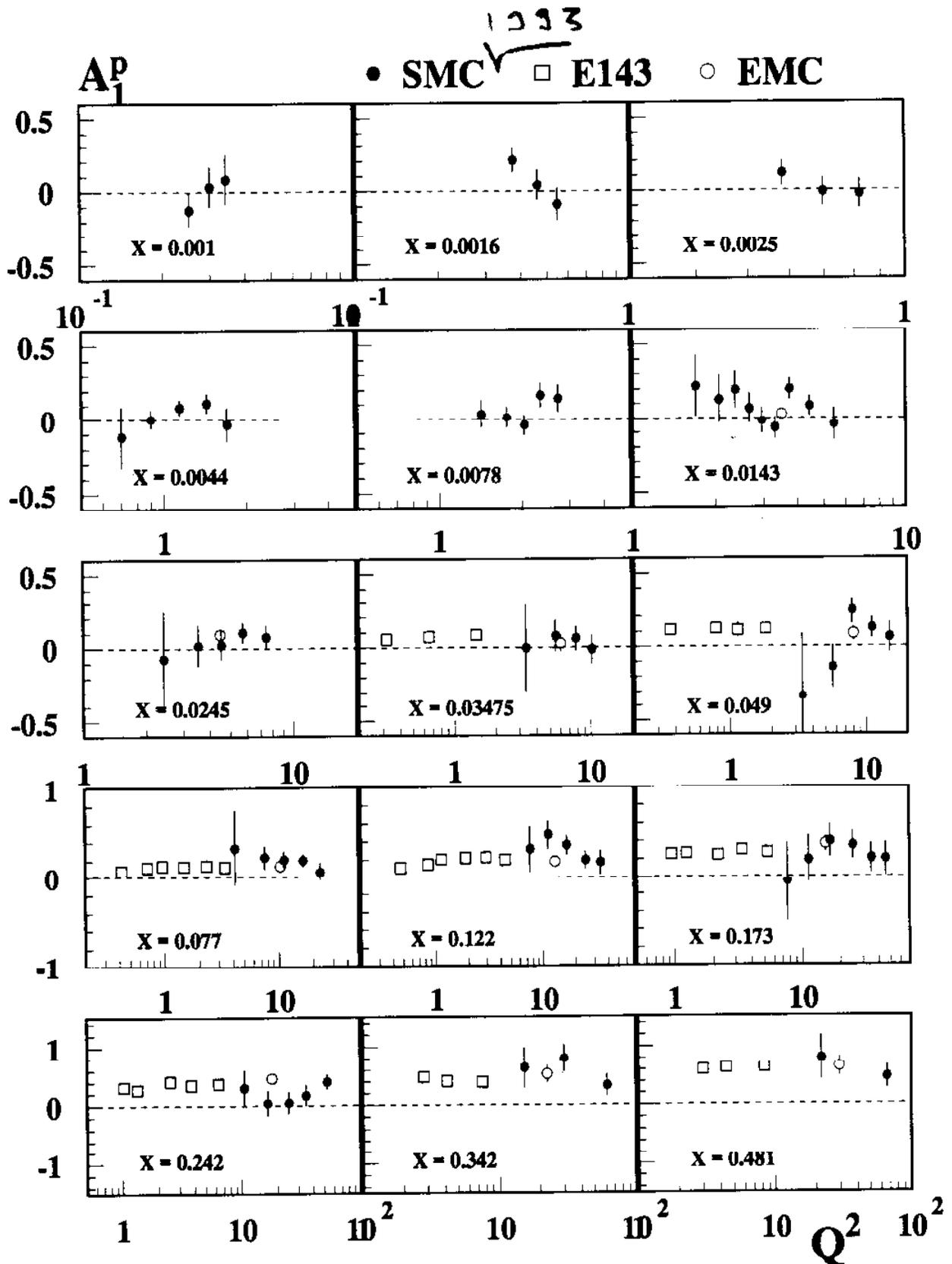
NA47 G1P 3 April 16h00 - 18 September 8h00



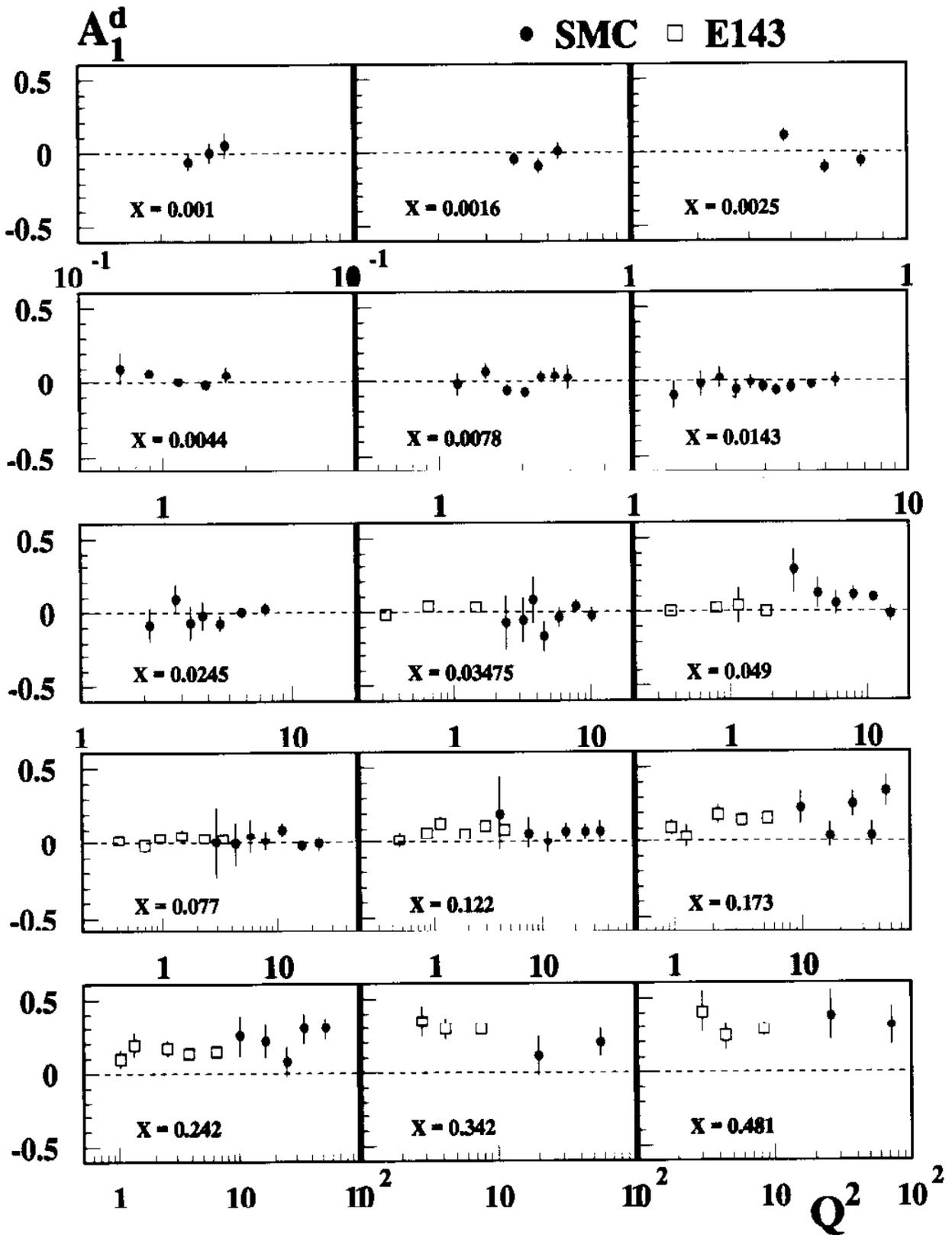
KINEMATIC RANGE



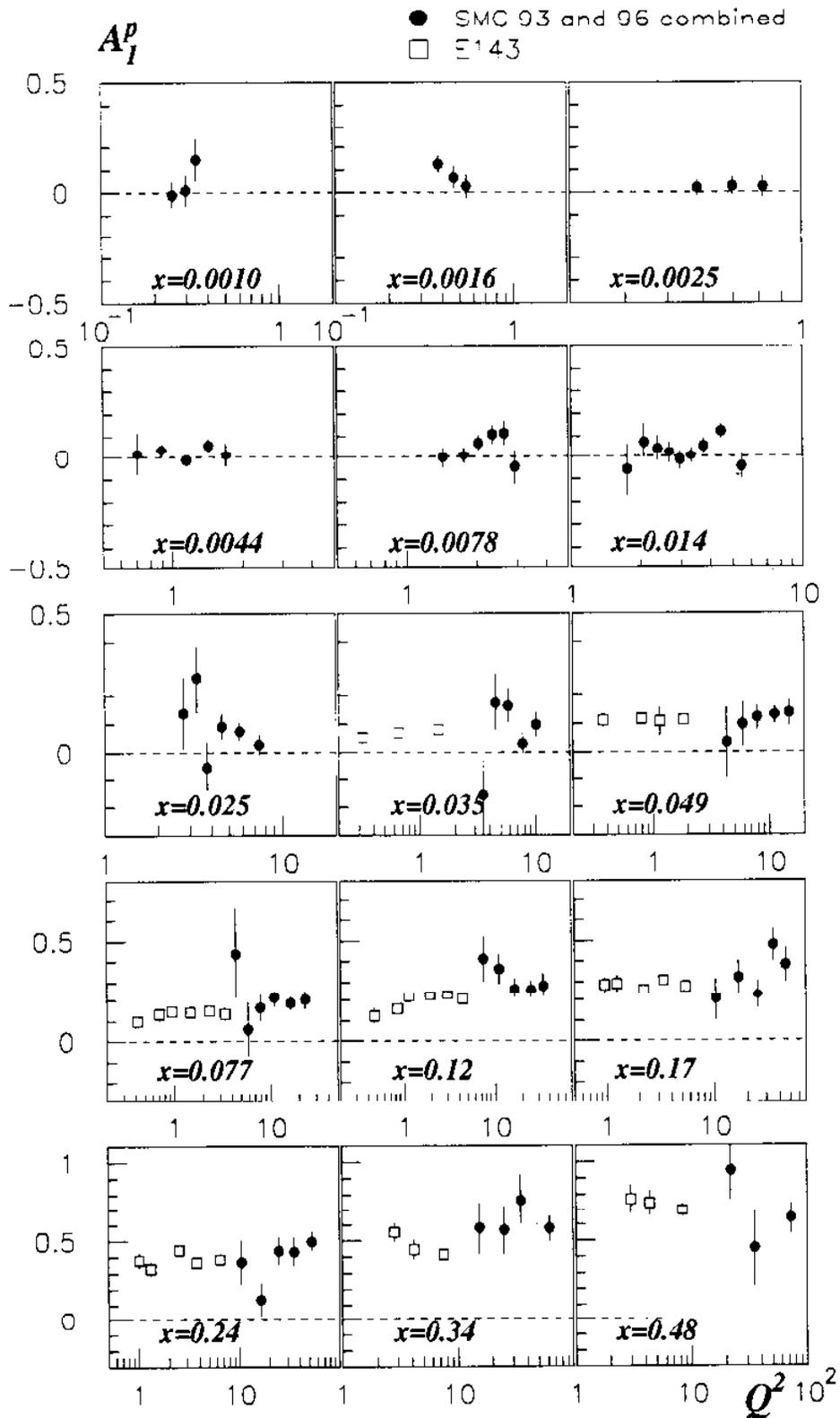
A_1^P VS Q^2



A_1^d VS Q^2



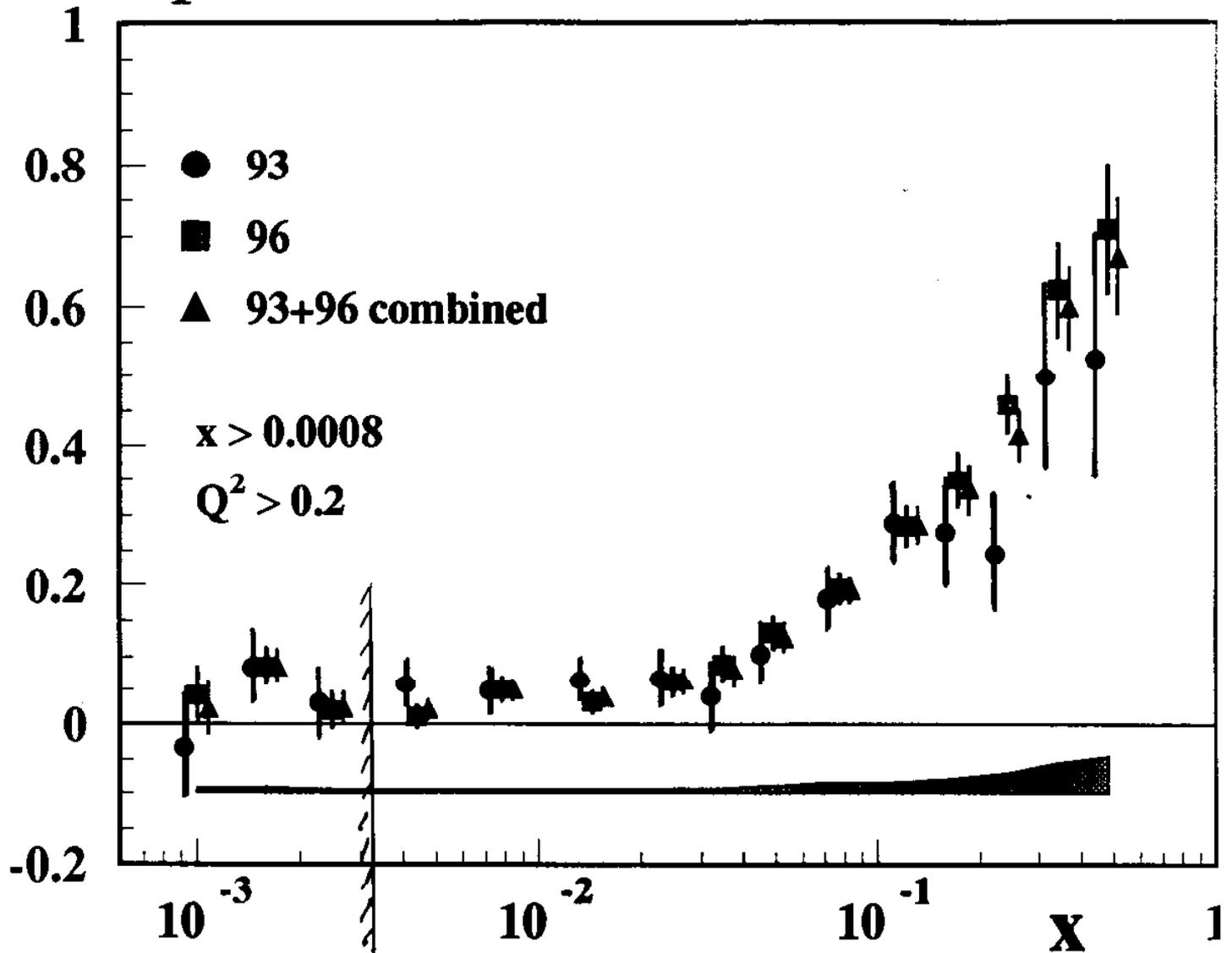
A_1^p VS Q^2 E143 SMC(1993-1996) preliminary



SMC 93 & 96

A_1^P with 3 lower x bins

preliminary



$Q^2 > 1 \text{ GeV}^2$

FROM A_1 TO g_1

$$A_1 \quad A_2 \Rightarrow g_1 :$$



$$g_1 = \frac{F_2}{2x(1+R)}(A_1 + \gamma A_2) \quad \gamma = \frac{2Mx}{\sqrt{Q^2}}$$

At SMC γ small; we find $A_2^p, A_2^d \approx 0 \dots$

... and use $A_2 \equiv 0 \quad \sigma A_2 \Rightarrow$ systematic

At SLAC γ larger; A_2^p, A_2^d, A_2^n are measured

A_1 or g_1/F_1 are calculated

F_2 and R (unpolarized) needed since $\frac{\Delta\sigma}{\sigma}$ is measured.

$$F_2(x, Q^2) :$$



From NMC, SLAC and BCDMS coverage is
 $0.0045 < x < 0.85$ and $0.5 < Q^2 < 200 \text{ GeV}^2$.

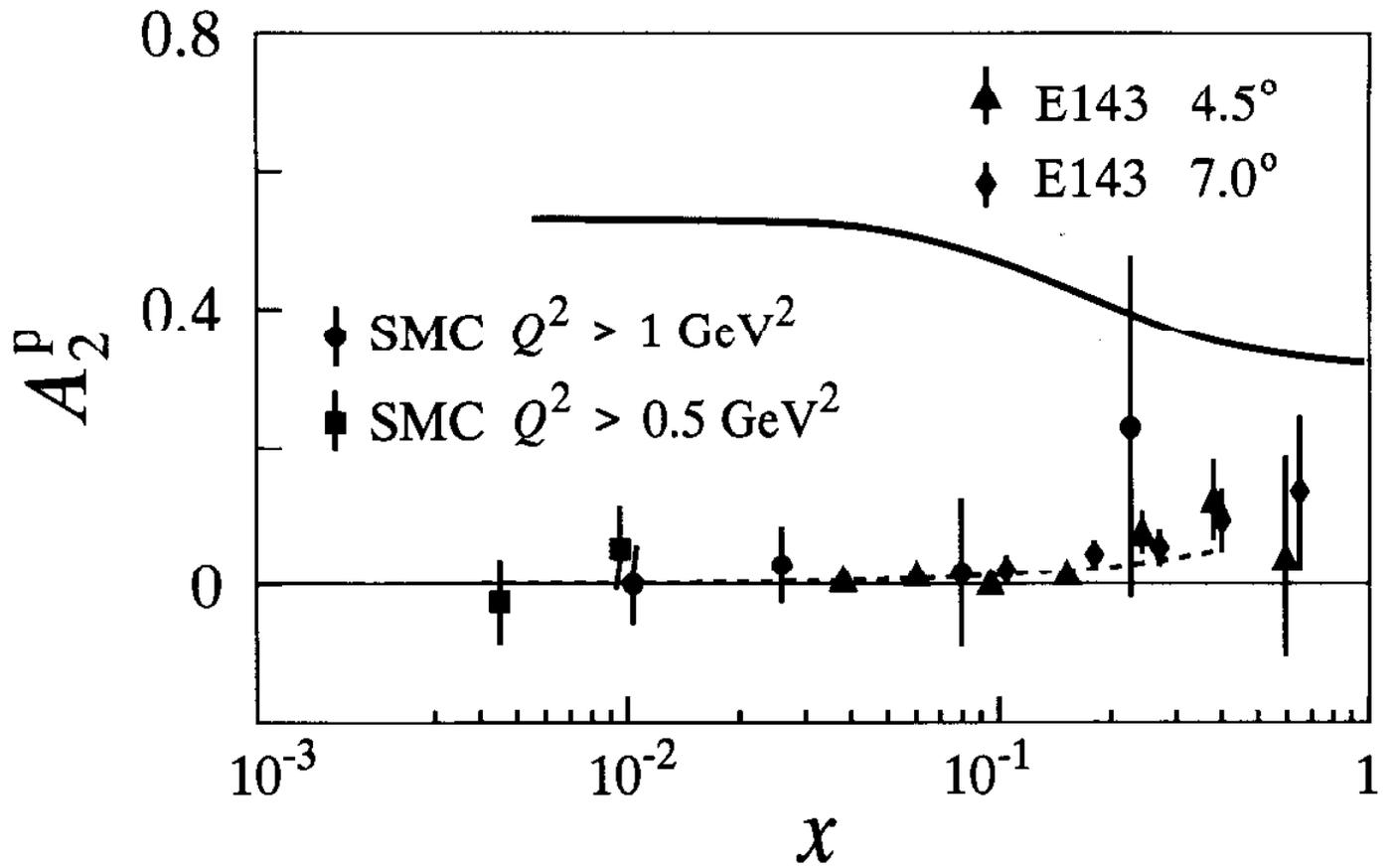
$$R(x, Q^2) :$$



SMC uses SLAC parametrisation.

Apart from Radiative Corr. and Evolution effects, g_1 is $\forall R$.

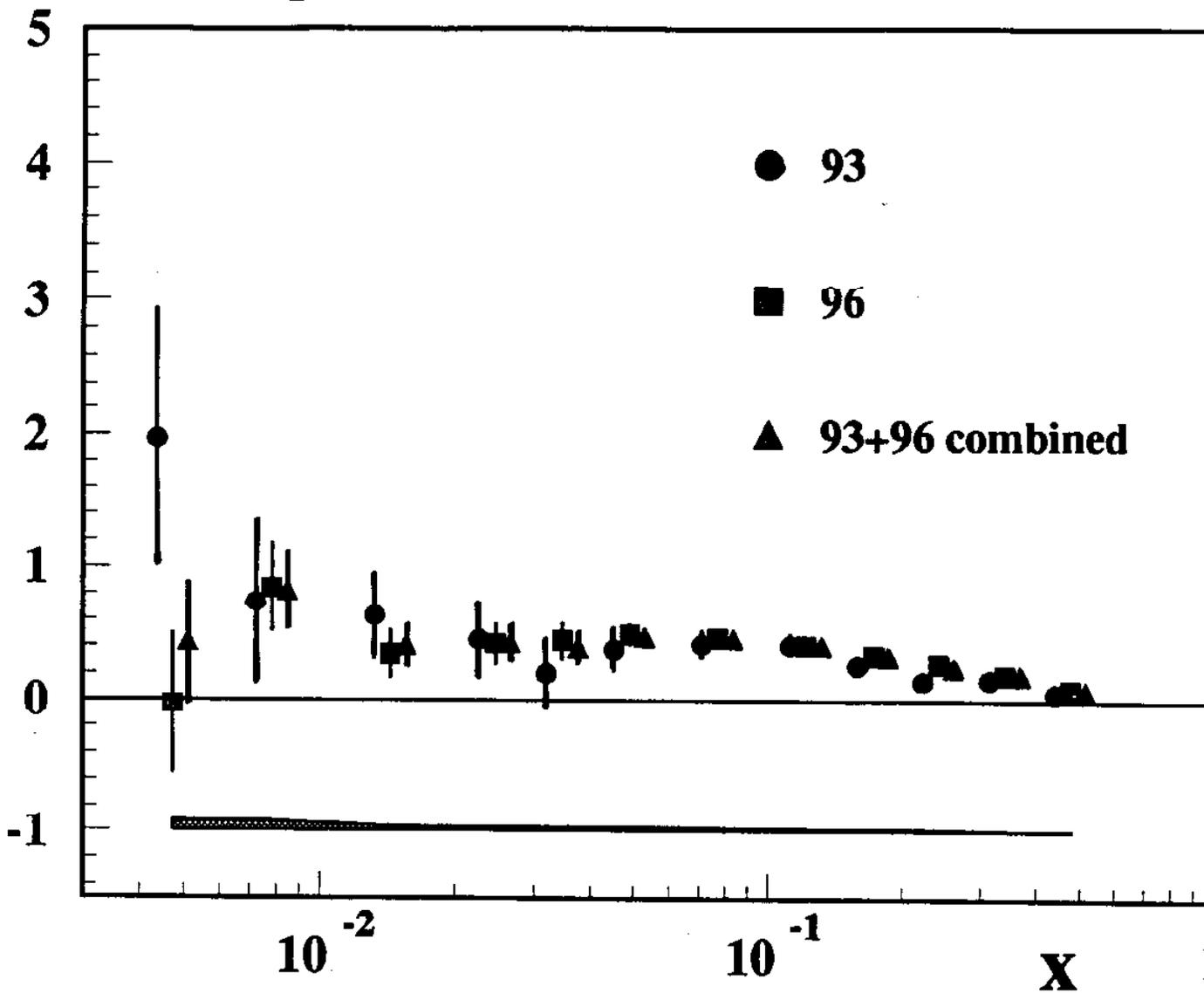
 A_2^P SMC E143



SMC 93 & 96

g_1^p at measured Q^2

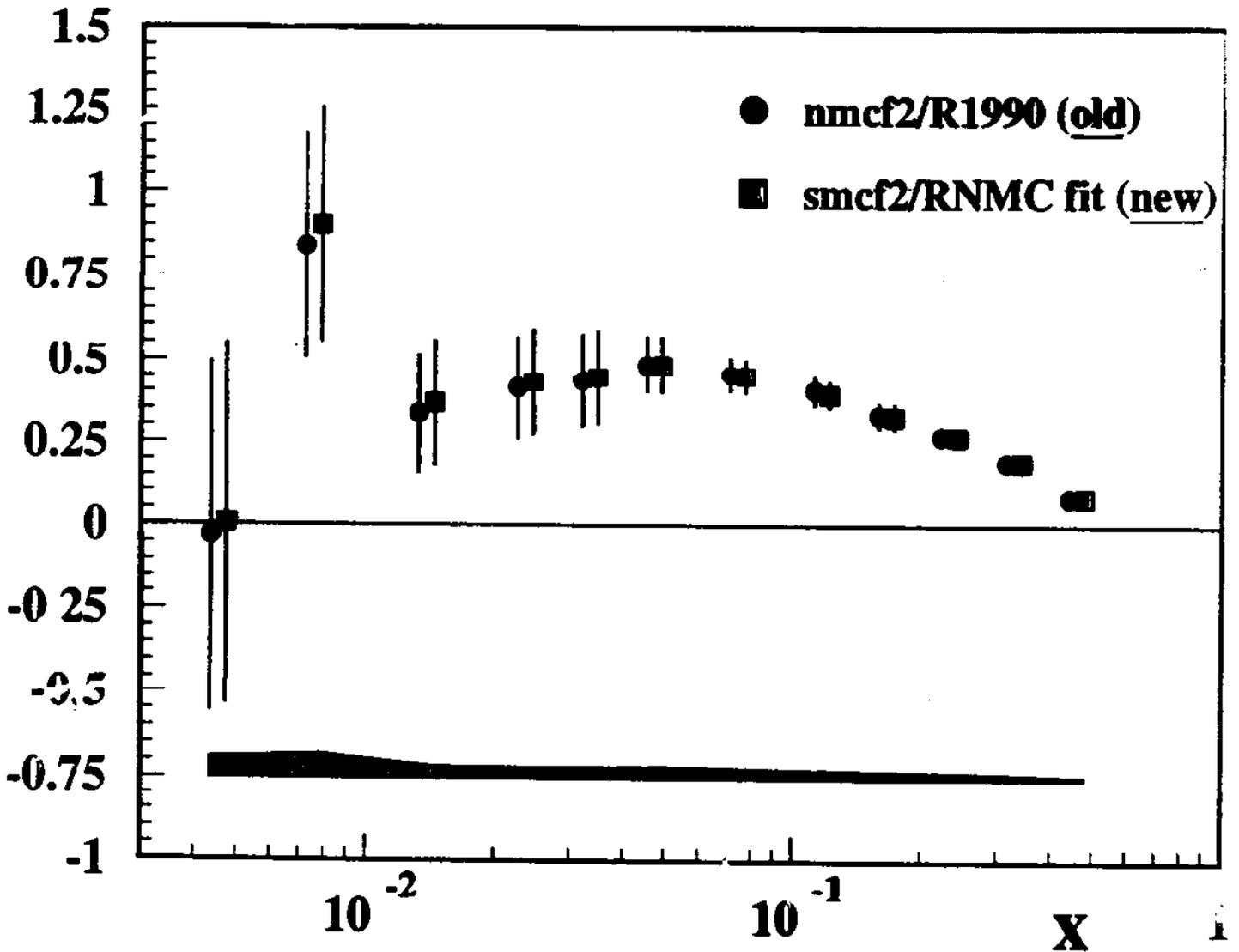
preliminary



SMC 1996

preliminary

P
 g_1 at measured Q^2



FROM $g_1(x, Q_m^2)$ TO $g_1(x, Q_0^2)$

EVOLUTION PROCEDURE

OLD

- Select Q_0^2 (SMC 10 GeV², SLAC 3 GeV²)

*• Evolution procedure independent of the evolution scheme
• $g_1(x, Q_0^2) = A \int_0^1 g_1^f(x, Q_m^2) + B \int_0^1 g_1^g(x, Q_m^2)$*

NEW

- QCD DGLAP NLO evolution of Ball Forte Ridolfi (BFR)
- Parametrization of Parton Distributions (at 1 GeV²) :

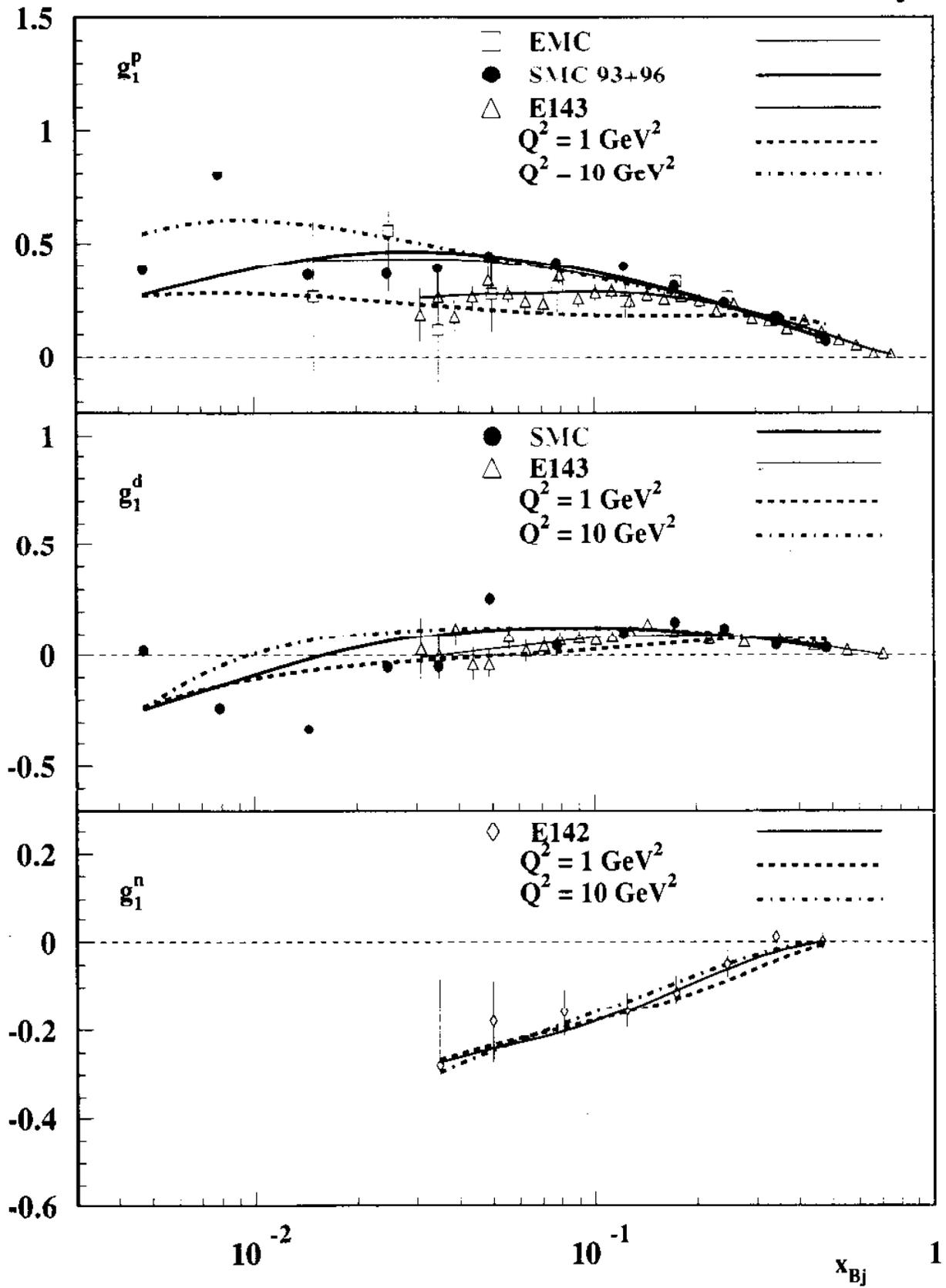
$$\Delta f(x, Q_0^2) = N_f \eta_f x^{\alpha_f} (1-x)^{\beta_f} (1+a_f x)$$

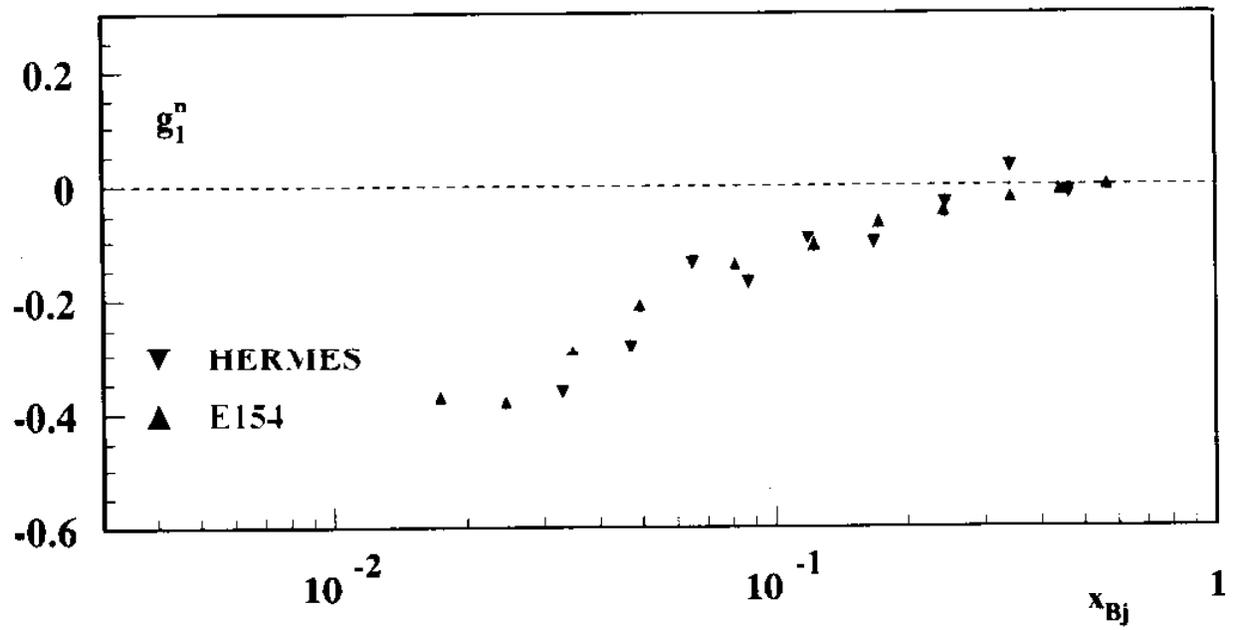
Δf stands for : Δq^{NS} (Quark Non Singlet), $\Delta \Sigma$ (Quark Singlet), Δg (Gluon)

- η_f = First moment of parton distribution
- N_f = Normalisation, for NS use neutron and hyperon β decays, assuming SU(3)
- Fix $\beta_g = 4$
- Coefficients and Splitting functions at NLO in AB scheme
- Included in the fit : EMC, SMC-p(93+96prelim), SMC-d(92,94,95), E143(29GeV,16GeV,9GeV), E142
- NEW : to evolve our data points, calculate :

$$g_1(x, Q_0^2) = g_1(x, Q_m^2) + [g_1(x, Q_0^2) - g_1(x, Q_m^2)]_{FIT}$$

SMC Proton 96 Preliminary





$$\Delta f = N \eta x^a (1-x)^b (1 + \underline{u_1} x)$$

MINUIT TASK: Feb 24, Separate NS with a_g=a_ns=0+SMC96

FCN= 90.50515 FROM MINOS STATUS=SUCCESSFUL 539 CALLS 1563 TOTAL
 EDM= 0.88E-04 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS	
				NEGATIVE	POSITIVE
1	xetaq	0.38132	0.36442E-01	-0.35217E-01	0.38009E-01
2	xaq	0.85971	0.31938		
3	xbeg	1.5673	0.80306		
4	xalq	-1.3901	0.10278		
5	xetaq	0.81666	0.25793	-0.24218	0.33533
6	xaq	-0.49410	0.27653		
7	xbeg	4.0000	constant		
8	xalq	0.	constant		
9	xansp	-0.84398E-01	0.98519E-01		
10	xbensp	1.5337	0.27986		
11	xalnsn	0.	constant		
12	xansn	0.25490	0.33720		
13	xbensn	3.7470	1.5396		
14	xalnsn	0.	constant		

ENTER MINUIT COMMAND:

 ** 4 **RETURN

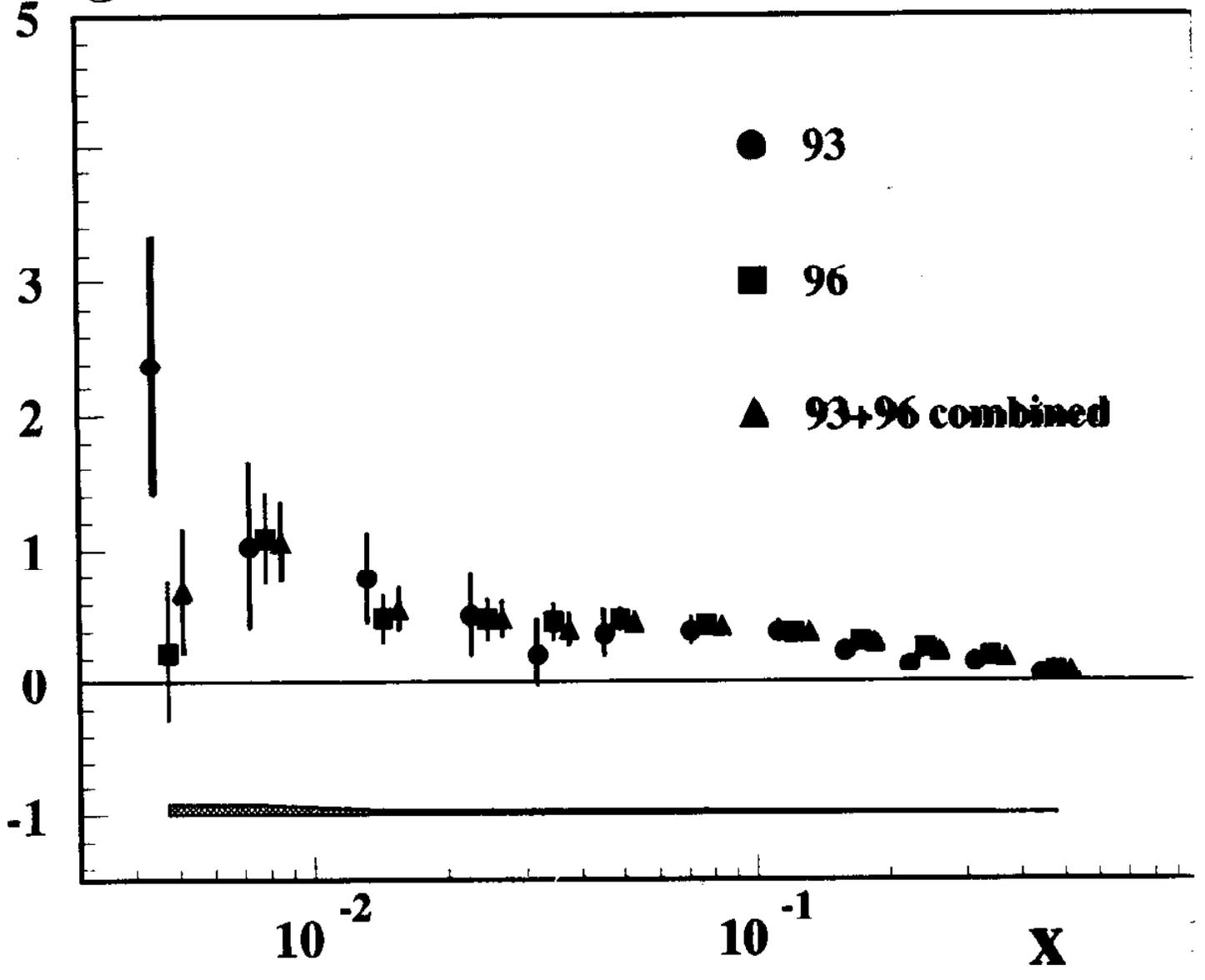
$\Delta \eta, \tau \neq 0$

$\tau_0 = 0.82$

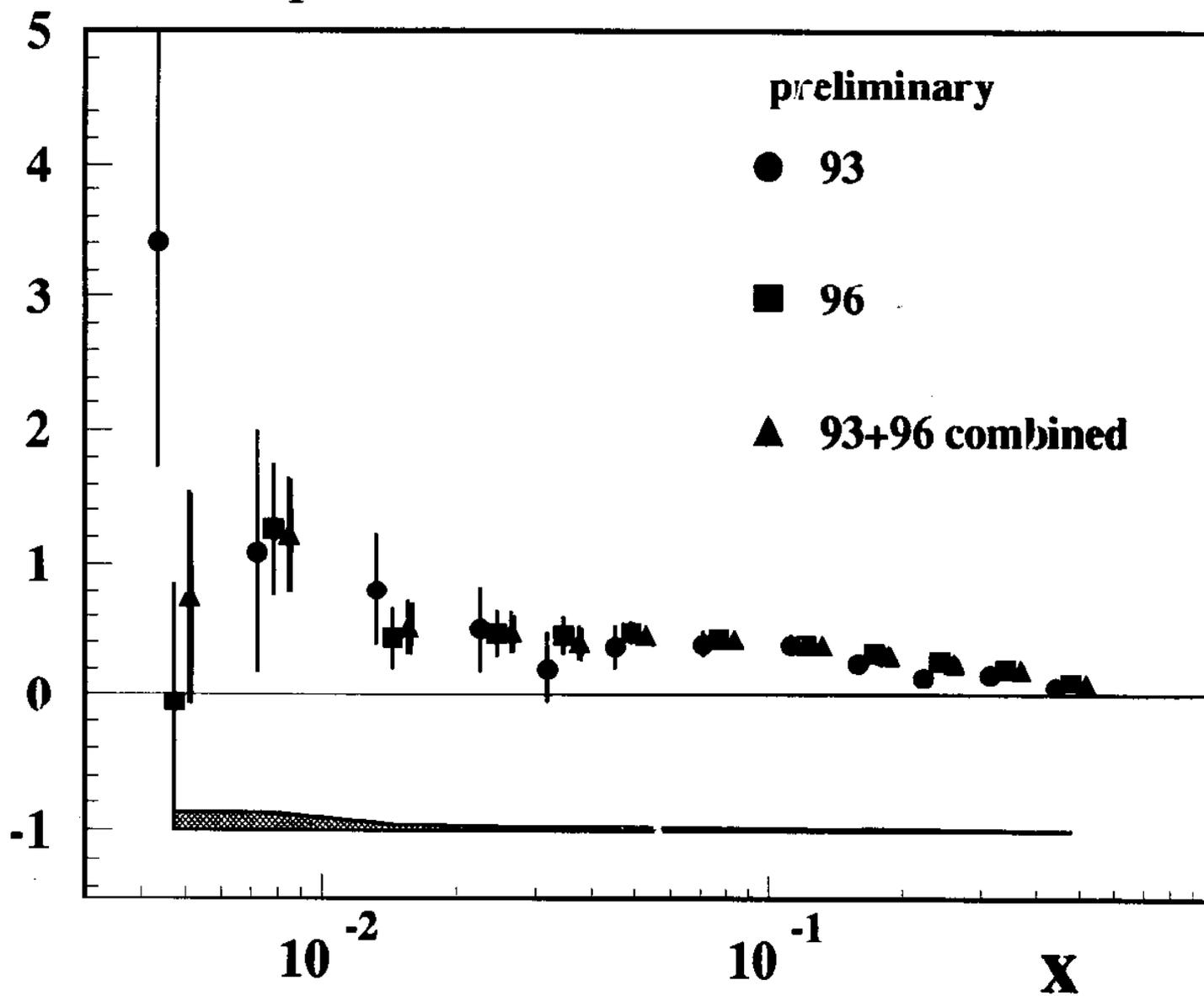
$\chi^2 = 90/103$

... now
 +.34
 -.24
 (0.80)
 #

g_1^F at $Q^2=10 \text{ GeV}^2$ Evolution BFR preliminary



g_1^p at $Q^2=10\text{GeV}^2$ A1 scales



FROM $g_1(x, Q_0^2)$ TO $\Gamma_1 = \int_0^1 g_1(x, Q_0^2) dx$

INTEGRATE/EXTRAPOLATE

- Integrate measured region :

($0.003 < x < 0.7$ SMC) or ($0.02 < x < 0.7$ SLAC)

- Extrapolate :

1. $x \rightarrow 1$ extrapolation NOT CRITICAL F_1 is small \rightarrow
contribution to Γ_1 small

$$A_1^p = 0.7 \pm 0.3$$

$$A_1^d = 0.4 \pm 0.6$$

Consistent with data and $|A_1| < 1$

2. $x \rightarrow 0$ assumes REGGE BEHAVIOUR

$$g_1 \sim x^\alpha ; 0 < \alpha < 0.5$$

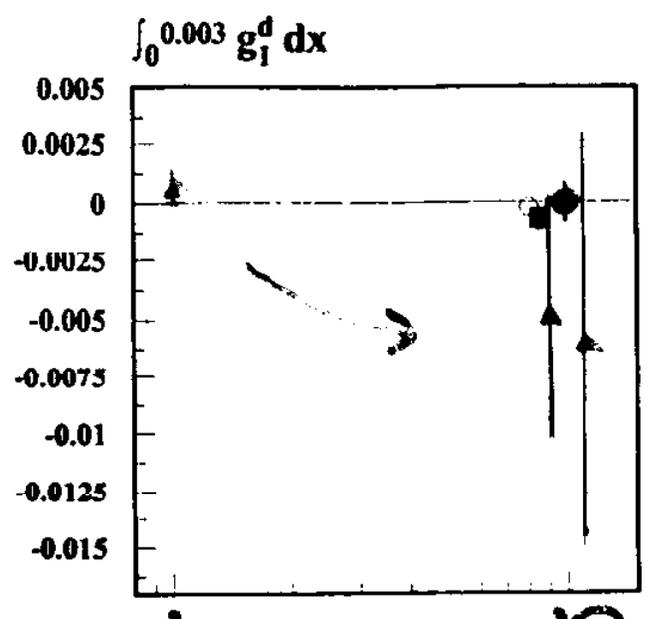
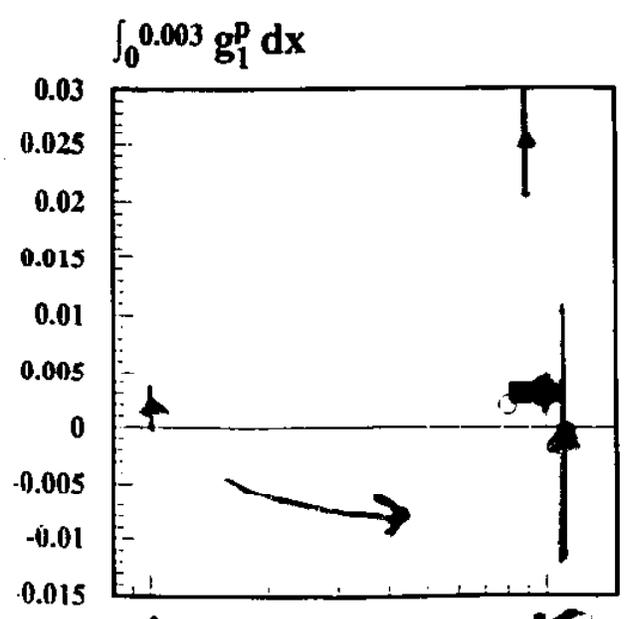
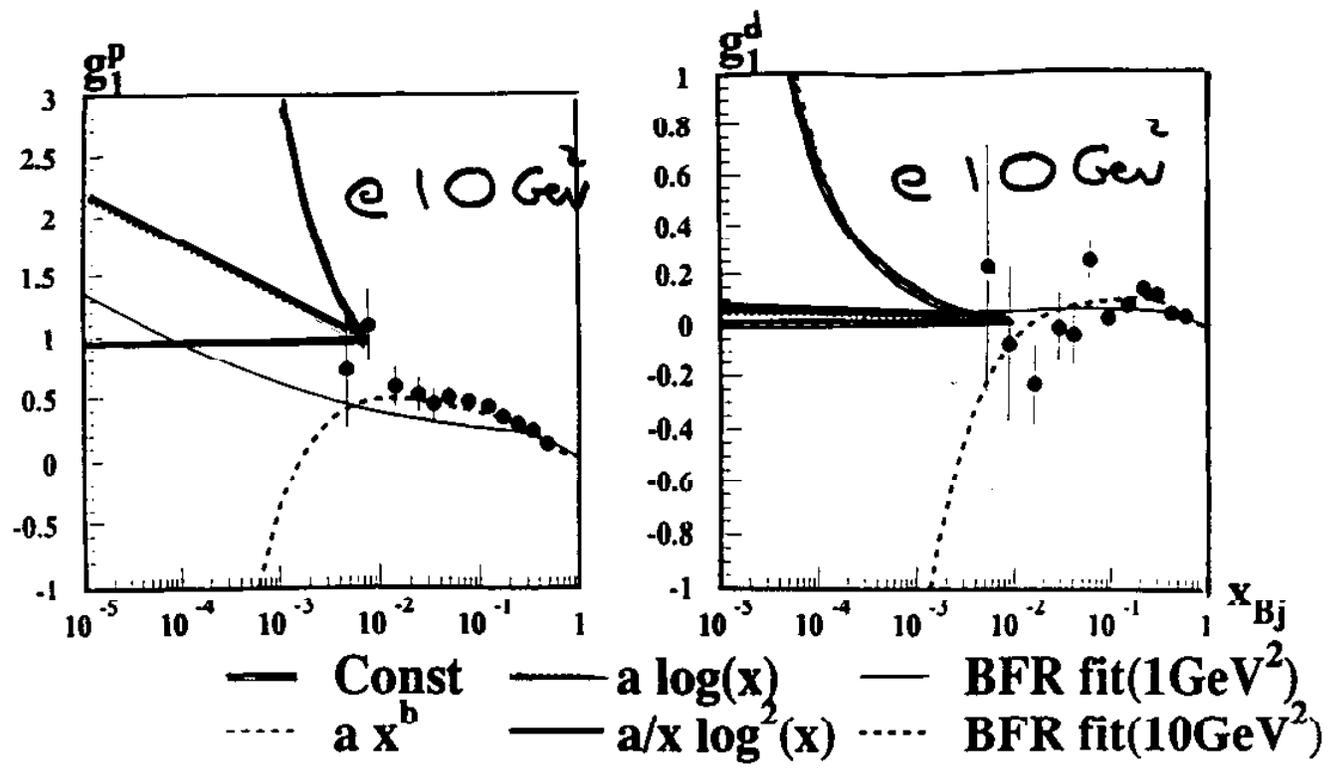
(Not OK at HERA for F_2 when $Q^2 \geq 0.3$) ?

SMC fits constant to two lowest- x g_1 data points and
assumes large uncertainty

- Uncertainty for $x \rightarrow 0$ extrapolation subject to discussion

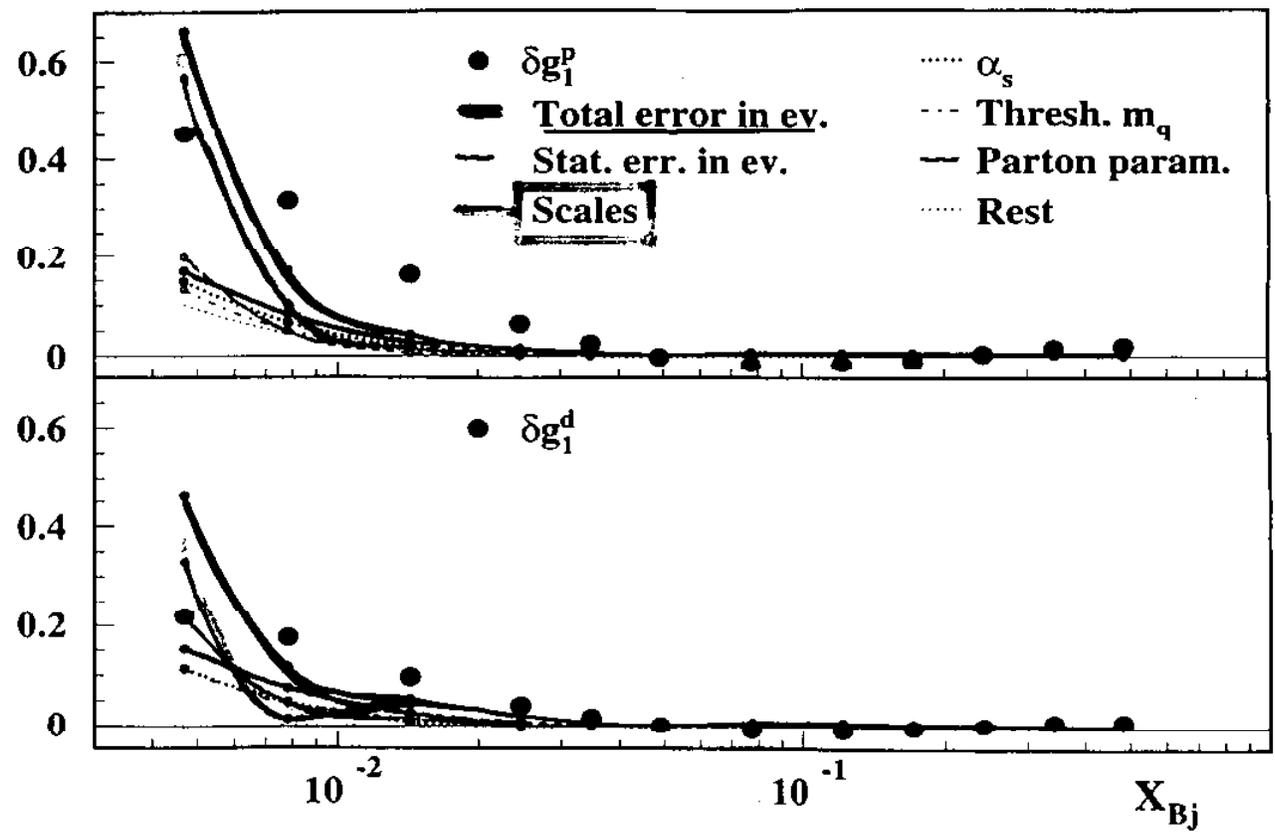
Altarelli Ball Forte Ridolfi, CERN-Th/96-345, hep-ph/9701289

Low x extrapolation



- $g_1 = \text{const } 10\text{GeV}^2$
- $g_1 = a x^b 10\text{GeV}^2$
- $g_1 = a \log(x) 10\text{GeV}^2$
- ▲ $g_1 = \text{const } 1.0\text{GeV} \text{ and evolved}$

errors on evolution



LOW x EXTRAPOLATION : $\int_0^{0.003} g_1(x) dx$

• $g_1^P = \text{Constant} \quad @ 10 \text{ GeV}^2$

$0.0042 \pm 0.0015 \quad (93)$

0.0028 ± 0.0007 $(93 + 96)$

• $g_1^P = ax^b \quad (0 < b < 0.5)$

0.0020 ± 0.0004

• $g_1^P = a \text{Log}(x)$

0.0031 ± 0.0006

• $g_1^P = a/(x \text{Log}^2(x))$

0.0254 ± 0.0050

• $g_1^P = \text{Constant} \quad @ 1 \text{ GeV}^2 \rightarrow \text{evolve (BFR) to } 10 \text{ GeV}^2$

(Proton) -0.0010 ± 0.0110 $(93 + 94)$

(Deuteron) -0.0066 ± 0.0099 $(92 + 94 + 95)$

1993 0.136 (0.013) (0.009) (0.005)

* 1996 0.153 (0.007) (0.009) (0.005)

0.0015 (0.0007)

* 1993+1996 0.149 (0.006) (0.009) (0.0045)

0.0029 (0.0007)

*PRELIMINARY

THEORY 0.170 (0.005)*

^(*) $\alpha_s(M_z^2) = 0.117(0.005)$, $g_a = 1.2601(0.0028)$, $F/D = 0.575(0.016)$, $n_f = 3$

SMC Γ_1^p @ 10 GeV^2 A_1^p SCALES

1993 0.139 (0.014) (0.010)

* **1996** 0.153 (0.007) (0.010)

* **1993+1996** 0.151 (0.007) (0.010)

*PRELIMINARY

THEORY 0.170 (0.005)*

^{*)} $\alpha_s(M_z^2) = 0.117(0.005)$, $g_a = 1.2601(0.0028)$, $F/D = 0.575(0.016)$, $n_f = 3$

$$* \boxed{1993+1996} \Gamma_1^p = 0.149 (0.012)$$

$$\boxed{1992+1994+1995} \Gamma_1^d = 0.041 (0.008)$$

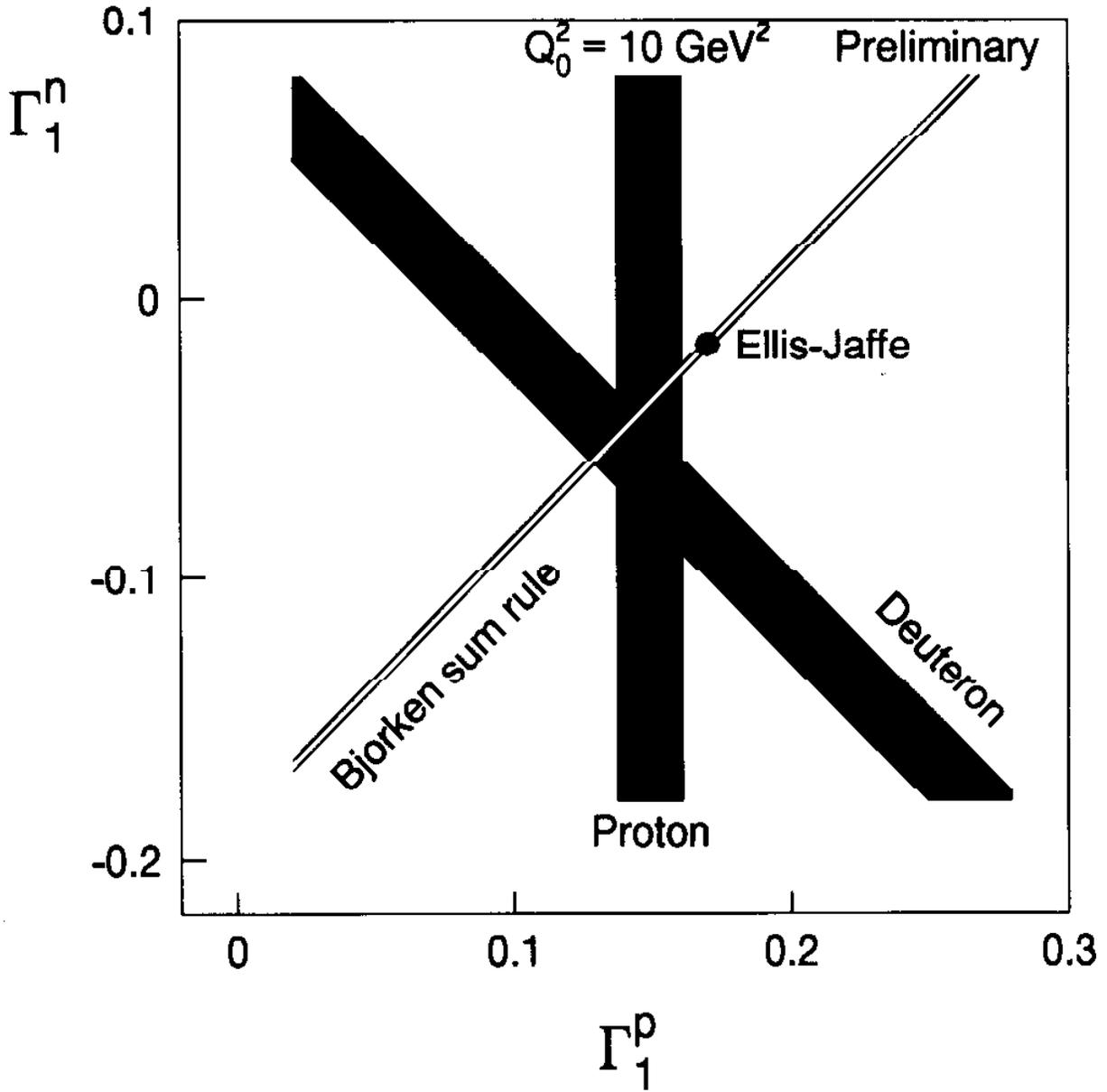
$$* \text{BJORKEN} = 0.209 (0.026)$$

*PRELIMINARY

$$\boxed{\text{THEORY}} 0.187 (0.002)^*$$

^(*) $\alpha_s(M_z^2) = 0.117(0.005)$, $g_a = 1.2601(0.0028)$, $F/D = 0.575(0.016)$, $n_f = 3$

SMC @ 10 GeV²



AXIAL QUARK CHARGES FROM SMC @ 10 GeV²

$$*a_0^p = 0.41 (0.11)$$

$$a_0^d = 0.29 (0.08)$$

$$* \langle a_0 \rangle = 0.33 (0.07)$$

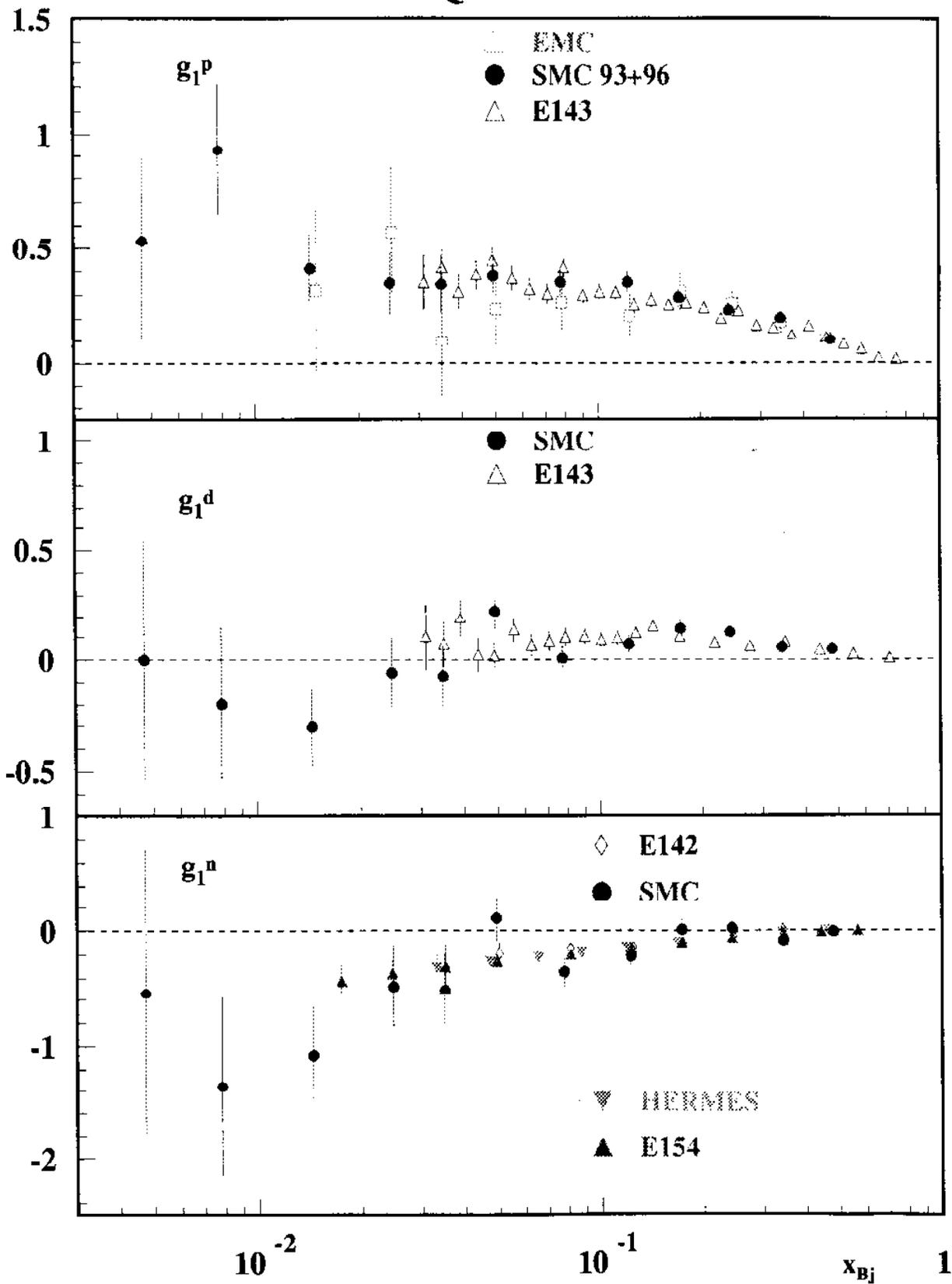
$$*a_s^p = -0.06 (0.04)$$

$$a_s^d = -0.10 (0.03)$$

$$* \langle a_s \rangle = -0.08 (0.03)$$

***PRELIMINARY**

World Data at $Q^2 = 5 \text{ GeV}^2$



- errors on g_i^p from SMC-96 reduced by ~ 2

- g_i^p does not rise at low x

- additional g_{i-96}^p & g_{i-95}^d bring " η_g " down to 0.8

- Γ_i^p gets extra systematics if NLO evolution is used for $0 < x < 0.003$

- World data set on g_i shows good agreement

- measuring g_1 at lower x and at different Q^2 is needed to constrain the QCD/NLO evolution